



Federal Aviation
Administration

Next **GEN**

THE BUSINESS CASE
for the
Next Generation Air Transportation System

FY 2014

From the Assistant Administrator

December 2014

The FAA estimates that Next Generation Air Transportation System (NextGen) improvements will generate \$133 billion in benefits to National Airspace System (NAS) users between 2013 and 2030. Those improvements will cost the FAA and NAS users \$29 billion over the same time period. After discounting to present value, that is a benefit-to-cost ratio of more than 3:1.



I am pleased to provide you with this year's Business Case for NextGen where we update and report these estimates annually. The Business Case for NextGen is a comprehensive view of the costs and benefits associated with modernizing and transforming the NAS. It provides the only system-wide analysis of benefits and costs by combining data from a number of sources, including business cases for individual programs, third-party studies, and system-wide modeling.

NextGen expenditures between 2013 and 2030 are estimated at \$29 billion (\$14 billion for the FAA and \$15 billion for aircraft operators). These cost estimates include FAA capital costs, related FAA operations costs, and the cost to users of equipping their aircraft with NextGen avionics.

Those expenditures are estimated to generate \$133 billion in benefits. Benefits come from reduced delay compared to a baseline forecast, improved flight efficiency, and future cost savings for the FAA. The benefit estimates include the impact of baselined capital improvement programs, such as Automatic Dependent Surveillance-Broadcast (ADS-B) Out; longer-term improvements that are not yet baselined, such as ADS-B In; and non-capital improvements, such as Performance Based Navigation.

The FAA's goal is to provide the latest and best estimates of NextGen costs and benefits. To ensure that cost-and-benefits estimates are current, we analyze them annually using the most up-to-date values that consider the various stages of maturity of NextGen programs as they are updated.

In addition to program plans, other changing factors influence the values included in the economic analysis of NextGen:

- Forecasts of future fleet and air traffic,
- Current values for airline operating costs, including fuel,
- Current values for passenger time, and
- Improvements to the FAA's system-wide analysis capability (SWAC)

Compared to last year's Business Case, estimated NextGen benefits through 2030 are about 25 percent lower, \$133 billion compared to \$182 billion. This is in particular due to changes to projected funding and lower traffic forecasts and is further explained in Appendix C.

NextGen improvements in technology and procedures represent a widespread, transformative change in the management and operation of the way we fly. Aviation contributes \$1.3 trillion to the U.S. economy, generates more than 10.2 million jobs with earnings of nearly \$400 billion, and makes up 5.2 percent of our gross domestic product. The aerospace sector is a vital element in the country's economy. Support for NextGen is essential as we forge the next generation of flight and maintain aviation's vitality in the 21st century.

Should you have any questions about the information reported in this document, please contact me or Roderick D. Hall, Assistant Administrator for Government and Industry Affairs.


Edward L. Bolton, Jr.

WHY NEXTGEN MATTERS

The movement to the next generation of aviation is being enabled by a shift to smarter, satellite-based and digital technologies and new procedures that combine to make air travel more convenient, predictable and environmentally friendly.

As demand for our nation's increasingly congested airspace continues to grow, NextGen improvements are enabling the FAA to guide and track aircraft more precisely as they fly on more direct routes. NextGen enhances safety, reduces delays, saves fuel and reduces aircraft exhaust emissions. NextGen is also vital to preserving and strengthening aviation's significant contributions to our national economy.

NEXTGEN PROVIDES A BETTER TRAVEL EXPERIENCE

- NextGen means less time sitting on the ground and holding in the air. NextGen technology and procedures are shaving crucial minutes off flight times, which translates into money saved and a better overall experience for the traveling public and aviation community.
- NextGen enables the sharing of real-time data about weather, the location of aircraft and conditions throughout the National Airspace System. We get the right information to the right people at the right time, helping controllers and operators make better decisions and improve on-time performance.
- NextGen is better for the environment. Flying is becoming quieter, cleaner and more fuel-efficient. Operators are beginning to use alternative fuels and new equipment and procedures, reducing our adverse impact on the environment. More precise flight paths are also helping limit the numbers of people impacted by aircraft noise.

NEXTGEN PRESERVES AVIATION'S ECONOMIC VITALITY

- Our nation's economy depends on aviation. NextGen capabilities in place today are the foundation for continually improving and accommodating future air transportation needs while strengthening the economy locally and nationally with one seamless, global sky.
- Airports are economic engines for the communities they serve, bringing visitors and commerce. NextGen is providing increased access, predictability and reliability, and enhancing airport operations across the country.

NEXTGEN ENHANCES SAFETY

- The FAA's top priority is ensuring safe skies and airfields, and NextGen innovation and improvements are delivering just that. NextGen is providing air traffic managers and pilots with the tools to proactively identify and resolve weather issues and other hazards.
- NextGen enables us to better meet our national security needs and ensure that travelers benefit from the highest levels of safety.



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INTRODUCTION



The nation's economy depends on a healthy aviation industry for the transportation of passengers and cargo. The U.S. National Airspace System (NAS) is one of the safest and most efficient in the world today. A number of changes are required to ensure that it remains safe and efficient into the future. During the past several decades, increases in demand have begun to strain some of the system's congested resources, often resulting in longer travel times and increased flight delays. At the same time, high oil prices and environmental concerns have led the aviation industry to look for more fuel efficiencies. Fortunately, improved technology is available to help alleviate these problems. GPS-based surveillance and navigation, digital communications and new decision support tools are emerging as ways to help meet the goals of reduced delays, increased efficiency and continued safety.

NextGen is the modernization of the air transportation system through improvements to air traffic management (ATM) technologies and procedures, airport infrastructure, and includes environmental, safety and security-related enhancements. NextGen changes will transform the NAS, making it less reliant on radar surveillance, ground-based navigation systems and voice communications.

This report presents the FAA's business case for the ATM elements of NextGen. By addressing only the ATM aspects of NextGen, we focus on the costs of the improvements that are

most directly borne by the FAA and system users. We consider the costs and benefits of addressing the shortfalls of the current system with new technologies.

NextGen has many components. It encompasses multiple programs, procedures and systems at different levels of maturity. The business case will focus on those improvements that are described in the NextGen Mid-Term Concept of Operations for the NAS [1] and in the 2014 NextGen Implementation Plan [2]. These improvements are generally planned for initial deployment between 2013 and 2020. Implementing and maintaining them is expected to cost the FAA and aircraft operators \$29 billion through the year 2030. During that period, these improvements are expected to generate \$133 billion in total benefits. Applying a 7 percent discount rate, and taking the difference between the present value of benefits and costs, we find that NextGen mid-term improvements have a Net Present Value of \$41 billion. This translates to \$3.40 in benefits for every \$1 invested.

This report revises a 2013 estimate of the costs and benefits of NextGen mid-term improvements. Revisions include updates to the FAA's capital budget, updated traffic and fleet forecasts, updated economic factors, improvements to the fast-time model used to estimate most of the operational benefits, changes to planned deployment dates for various operational improvements (OI), and changes to specific program business cases that were incorporated into this analysis.



“The nation’s economy depends on a healthy aviation industry for the transportation of passengers and cargo.”

NEXTGEN: TOMORROW AT A GLANCE

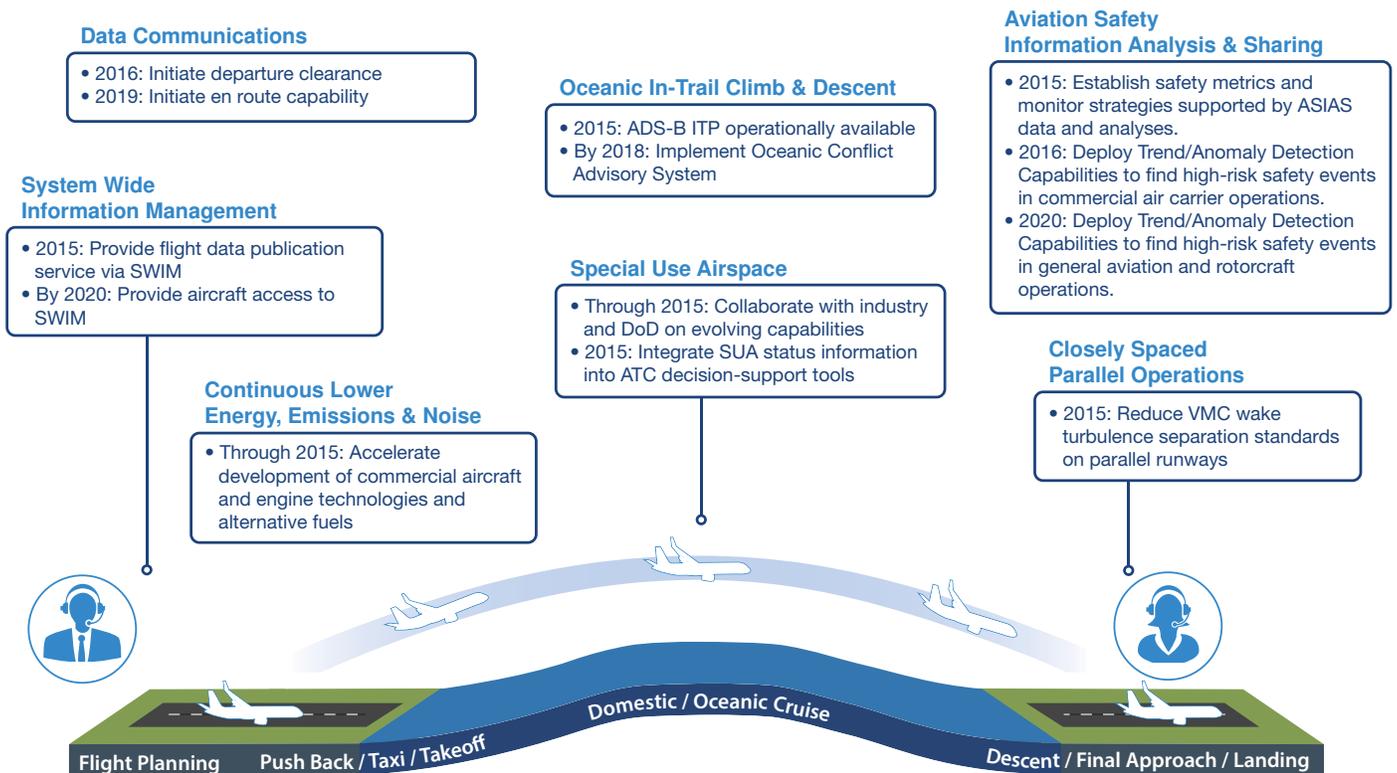


Figure 1. Representative NextGen Improvements by Phase of Flight

NextGen is transforming the NAS through a number of OIs, affecting every phase of flight, as shown in Fig. 1. These OIs address shortfalls in various categories, which are grouped into 11 portfolios:

IMPROVED SURFACE OPERATIONS

The Improved Surface Operations portfolio focuses on improved airport surveillance information, automation to support airport configuration management and runway assignments, and enhanced cockpit displays to provide increased situational awareness for controllers and pilots.

TIME-BASED FLOW MANAGEMENT

Improvements in the Time-Based Flow Management portfolio will enhance NAS efficiency by improved metering of flights using time instead of distance. In the near term, these changes will leverage the capabilities of the current Traffic Management Advisor tool, a system that the FAA has deployed to all contiguous U.S. air route traffic control centers.

PERFORMANCE BASED NAVIGATION

The Performance Based Navigation (PBN) portfolio leverages state-of-the-art navigation technologies, such as satellite-based Area Navigation and Required Navigation Performance (RNP), to improve access and flexibility for point-to-point operations.

ON-DEMAND NAS INFORMATION

The portfolio of On-Demand NAS Information will help ensure that airspace and aeronautical information is consistent across applications and locations and is available to all authorized subscribers and equipped aircraft.

COLLABORATIVE AIR TRAFFIC MANAGEMENT

The Collaborative Air Traffic Management portfolio will better assist NAS operators and FAA traffic managers in managing daily capacity issues such as congestion, special activity airspace,

and weather. Enhanced automation will deliver routine information digitally.

IMPROVED MULTIPLE RUNWAY OPERATIONS

The Improved Multiple Runway Operations portfolio is designed to improve runway access with improved technology, updated standards, safety analysis, and modifications to air traffic monitoring tools and operating procedures. It will enable more arrival and departure operations at airports with multiple runways, thereby reducing delays.

IMPROVED APPROACHES AND LOW-VISIBILITY OPERATIONS

The Improved Approaches and Low-Visibility Operations portfolio addresses ways to increase access and flexibility for approach operations through a combination of procedural changes, improved aircraft capabilities and better precision approach guidance.

SEPARATION MANAGEMENT

Improvement in the Separation Management portfolio will provide controllers with tools to manage aircraft in a mixed

environment of varying navigation equipment and wake performance capabilities.

ENVIRONMENT AND ENERGY

The Environment and Energy portfolio includes activities leading to the establishment and implementation of the NextGen Environmental Management System, and supports the development of biofuels and more efficient airframe and engine designs.

SYSTEM SAFETY MANAGEMENT

The System Safety Management portfolio develops and implements policies, processes, and analytical tools that the FAA and industry will use to ensure changes introduced with NextGen enhance or maintain safety while delivering benefits.

NAS INFRASTRUCTURE

The NAS Infrastructure Portfolio contains key transformational and infrastructure sustainment capabilities that are critical to the success of NextGen. The NAS Infrastructure Portfolio contains capabilities that fall into the following infrastructure categories: Communications, Oceanic, Information Management, Weather and Facilities.



BENEFIT-COST ANALYSIS OF MID-TERM IMPROVEMENTS



OVERVIEW

The cost and benefit calculations underlying the business case have been developed based on the plans described in the FAA's 2011 Mid-Term Concept of Operations and the 2014 NextGen Implementation Plan. The capabilities that make up the NextGen portfolios will work jointly to deliver the performance improvements described by these documents. Changing the deployment schedule for any enabling technology may alter the timing and magnitude of the benefits derived from the others. Although each capital program in the FAA is required to demonstrate a positive return on investment on a stand-alone basis before going forward, we believe a proper cost-benefit analysis of the entire NextGen mid-term must model all improvements jointly to capture their interactions.

Our modeling of the benefits and costs of NextGen relies on various inputs. We rely on traffic data from Fiscal Year 2012, along with traffic and fleet forecasts released in early 2013. Recommended economic values, such as those for passenger

value of time (PVT), are current as of early 2013. Finally, assumptions about program budgets and deployment schedules are derived from the FAA's Capital Investment Plan (CIP) [3] and the 2014 NextGen Implementation Plan. Changes in any of these input values will cause changes to our results. Indeed, this latest Business Case reflects the impact of substantial budget cuts and reductions in forecast traffic growth. The impact is that both the costs and benefits for many NextGen mid-term improvements are postponed.

Based on these latest inputs, our analysis shows that NextGen mid-term improvements will generate \$133 billion in benefits for the nation through 2030, compared to costs of \$29 billion.¹ Fig. 2 illustrates the annual cash flows for these benefits and costs. The following sections present these benefits and costs in more detail. A thorough discussion of the methodology used to generate them can be found in Appendices A and B.

¹ Unless otherwise noted, all years are fiscal years, and all values are in constant dollars, using Fiscal Year 2013 as the base year. Total cost is the estimated cost of deploying and maintaining NextGen mid-term operational improvements through 2030. This includes FAA Facilities and Equipment, Research and Development, and Operations and Maintenance costs, as well as the cost to system users for avionics upgrades. Total benefit includes the stream of benefits generated by these same operational improvements relative to a baseline scenario.

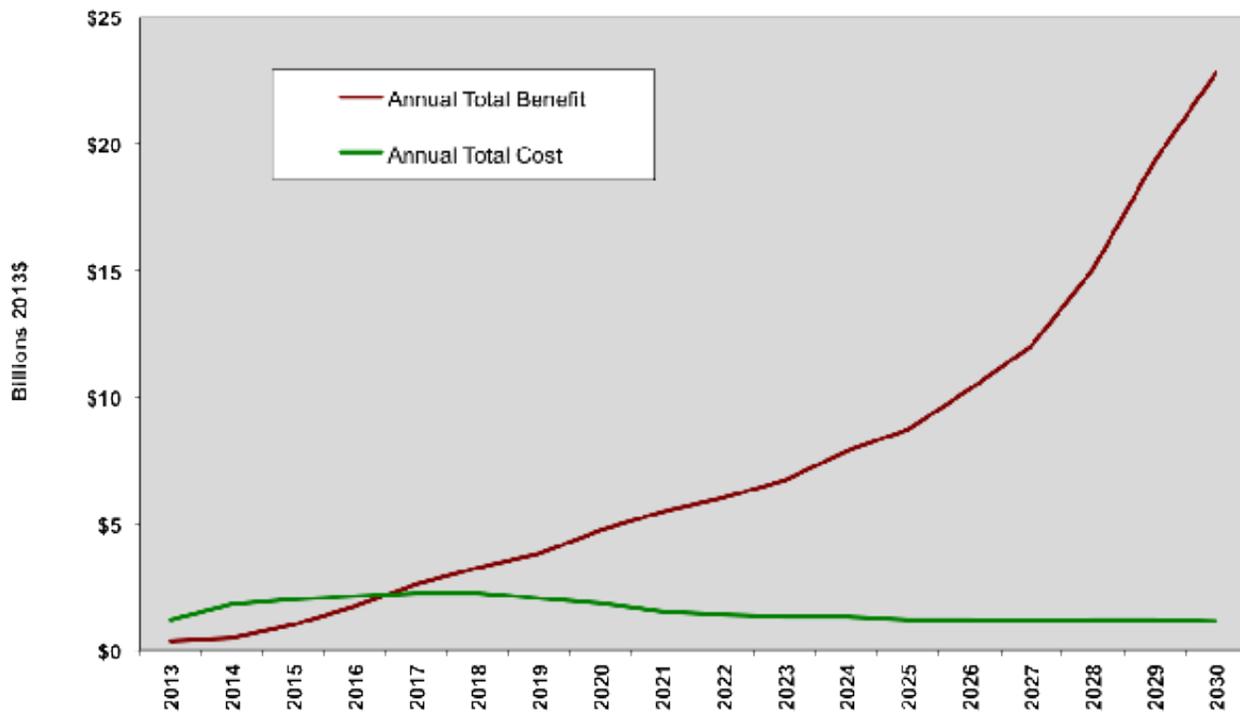


Figure 2. Annual Costs and Benefits of NextGen Mid-Term Capabilities

ESTIMATED BENEFITS OF NEXTGEN IMPROVEMENTS

The business case focuses on the direct benefits to aircraft operators, passengers and taxpayers from the rollout of NextGen improvements. These benefits include savings in aircraft direct operating cost (ADOC), PVT, and operating costs for air traffic control, along with improved safety and environmental benefits from reduced aircraft emissions.² The business case does not consider the second-order economic benefits that may accompany major technology initiatives, such as job creation and economic growth. We do not model planned NextGen improvements such as biofuels and improved engine technologies. The FAA does not directly provide these benefits, but the FAA supports these efforts with research funding.

The primary means of estimating these benefits is through fast-time simulation modeling, specifically the FAA’s System Wide Analysis Capability (SWAC). Evaluating NextGen benefits requires a comparison of two complete scenarios — a baseline scenario with no new NextGen improvements and a second scenario with the planned improvements. The benefits of the system improvements are then the difference between the two

scenarios in terms of the number of flights, number of cancellations, average time per flight and fuel consumed.

Because many NextGen benefits are based on the interaction of new communications, surveillance and navigation technologies rather than individual elements taken in isolation, estimating the NextGen benefits requires a comprehensive assessment of all improvements taken together. While we are continuously improving our model, we are not able to model all planned NextGen capabilities. We supplement our modeled benefits using program-specific investment analyses whenever necessary. We take care to avoid double counting.

Most NextGen benefits are related to the additional airspace capacity and efficiency that the new system is anticipated to provide. Time savings are valued in terms of dollars per minute, using estimates of ADOC and PVT. A consumer surplus approach assigns value to additional flights that will be enabled by greater system capacity. We also value the estimated benefit of reduced flight cancellations and reduced carbon dioxide emissions. Finally, estimates of FAA cost savings and improvements in system safety are adapted from other sources.

² While NextGen is expected to reduce emissions of particulate matter and oxides of nitrogen and sulfur, only reductions in carbon dioxide emissions have been included in this business case. Changes in noise exposure have not been considered.

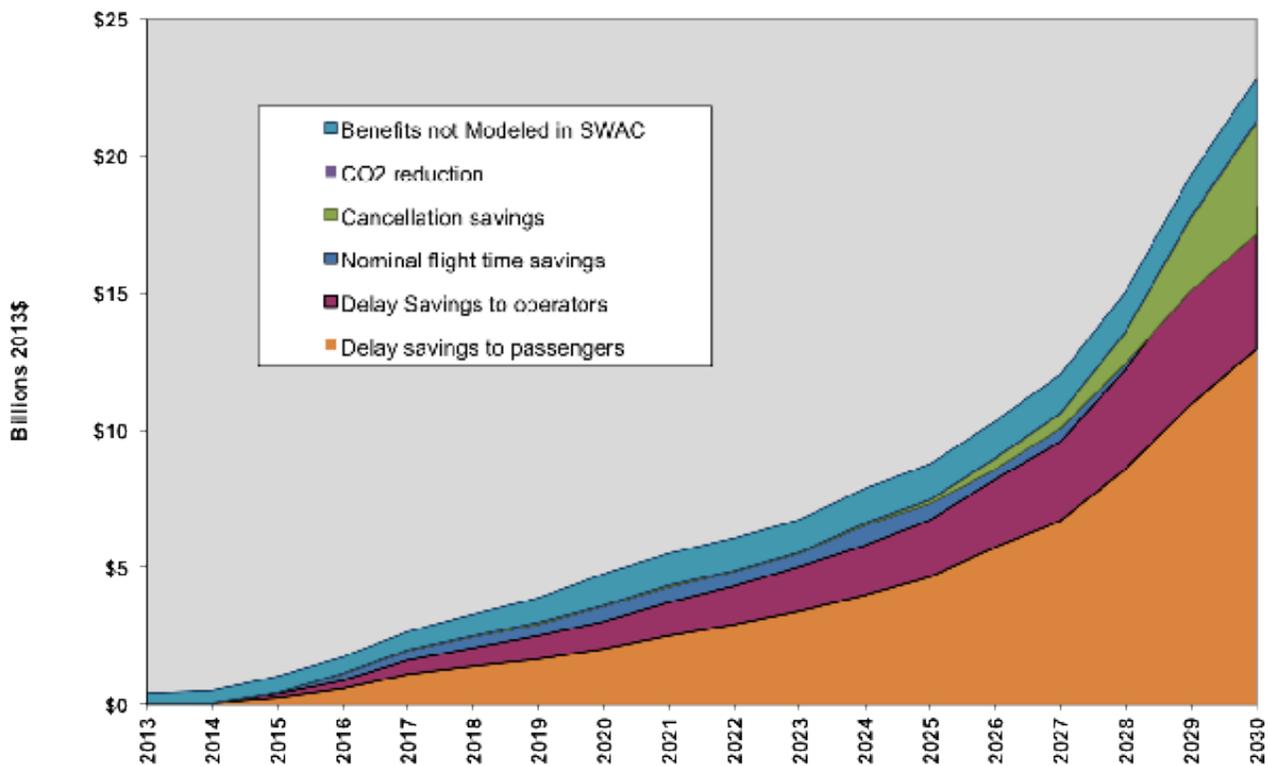


Figure 3. Annual Benefits of NextGen Mid-Term Capabilities

Expressed in constant inflation-adjusted dollars, the cumulative benefit estimates from 2013 through 2030 are

- Avoided delay — \$30.3 billion in ADOC and \$69.3 billion in PVT — by far the largest component³
- Reduced flight time — \$4.6 billion
- Fewer flight cancellations — \$9 billion
- Reduced carbon dioxide — \$400 million
- Other miscellaneous benefits not derived from FAA’s fast-time model, including safety improvements, FAA cost savings and others — \$18.9 billion.

Total benefits per year are shown in Fig. 3.

ESTIMATED COSTS OF NEXTGEN IMPROVEMENTS

Transforming the nation’s ATM infrastructure is a major undertaking. Ensuring that NextGen moves forward as scheduled — and therefore delivers benefits to NAS stakeholders as promised — will require timely investments on the part of both the government and aircraft operators.

³ In this cost-benefit analysis, delay refers to time in excess of that anticipated, no matter how small. While delays in excess of 15 minutes are all that are reported for operational purposes, all delays are included for FAA cost-benefit analyses.

Government investment includes the hardware and software required to implement NextGen, along with the system development and program management tasks associated with deploying this infrastructure. Adjusted for inflation, the FAA’s investment in NextGen mid-term improvements is projected to be \$13.6 billion from 2013 through 2030.

- Capital expenditures from the agency’s Facilities and Equipment (F&E) budget are expected to be \$8.9 billion.
- Other funding is included in the agency’s Research and Development (R&D) budget line. Through 2030, R&D and related expenditures on NextGen are projected to be \$700 million.
- We also estimate the amount that the FAA will need to spend on Operations and Maintenance (O&M) costs. These costs are projected to total about \$4 billion through 2030.

Investment by aircraft operators is also expected to be significant. This investment includes the purchase and installation of the avionics necessary to take advantage of NextGen capabilities. The technologies we consider are Automatic Dependent Surveillance–Broadcast (ADS-B) Out, ADS-B In, Data Communications and RNP. These costs are expected to total \$15 billion from 2013

through 2030. While most of these expenses will be borne directly by aircraft owners and operators rather than the government, they are an important component of the overall investment for NextGen, and it would be unfair to exclude them. These annual costs are shown in Fig. 4.

More details on the cost estimates and the methodology used to derive this information are in Appendix B.

INVESTMENT ANALYSIS

Deploying NextGen is a major capital project for the FAA and for the air transportation industry. It will take several years to install NextGen-ready avionics across the fleet, deploy the ground infrastructure and develop new procedures that support NextGen improvements. Over time, the annual benefits of NextGen will increase as new capabilities are brought into service. The chart in Fig. 5 shows the cumulative costs and benefits of deploying NextGen mid-term improvements.

Standard investment analysis requires that future costs and benefits be discounted to reflect the fact that a dollar paid or

received in the future is worth less than a dollar paid or received today. To calculate these discounted (or present) values, we use the 7 percent per year recommended by the Office of Management and Budget [4] to discount all benefits and costs. This approach yields the values shown in Fig. 6. Discounting affects far-term cash flows more than those in the near-term, so the cumulative benefits estimates are diminished more than the costs, as can be seen by comparing Figures 5 and 6.

Although significant investments will be required to prepare for NextGen operations, the cumulative discounted benefits will begin to exceed the cumulative discounted costs by 2020. By 2030, cumulative discounted benefits will exceed discounted costs by \$41 billion, for a benefit-to-cost ratio of 3.4-to-1. A common way to illustrate the annual impact of capital investment programs in present value terms is to show the cumulative discounted benefits less the cumulative discounted costs for each year, known as the Net Present Value (NPV), as shown in Fig. 7. This chart illustrates program breakeven in 2020 and the NPV of \$41 billion by 2030. To further demonstrate the strength of the business case, the chart also shows the analysis without considering

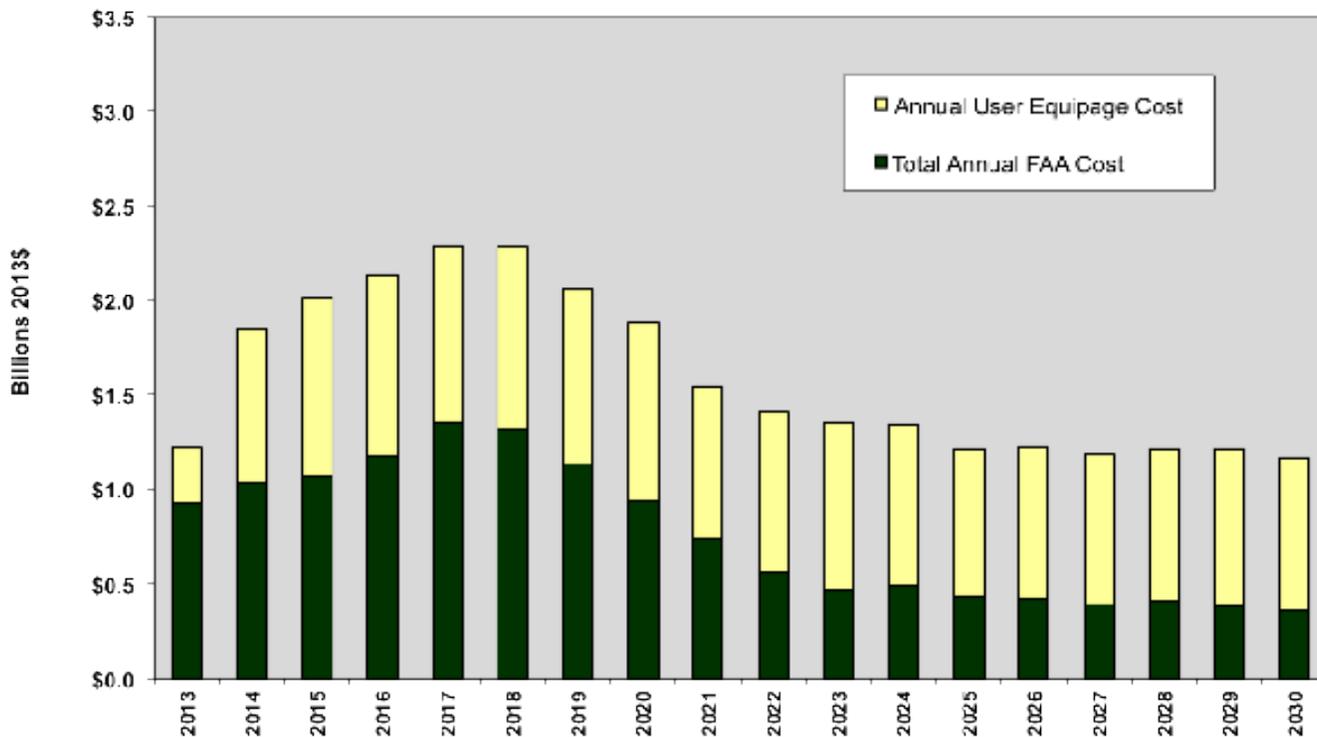


Figure 4. Annual Cost of NextGen Mid-Term Capabilities

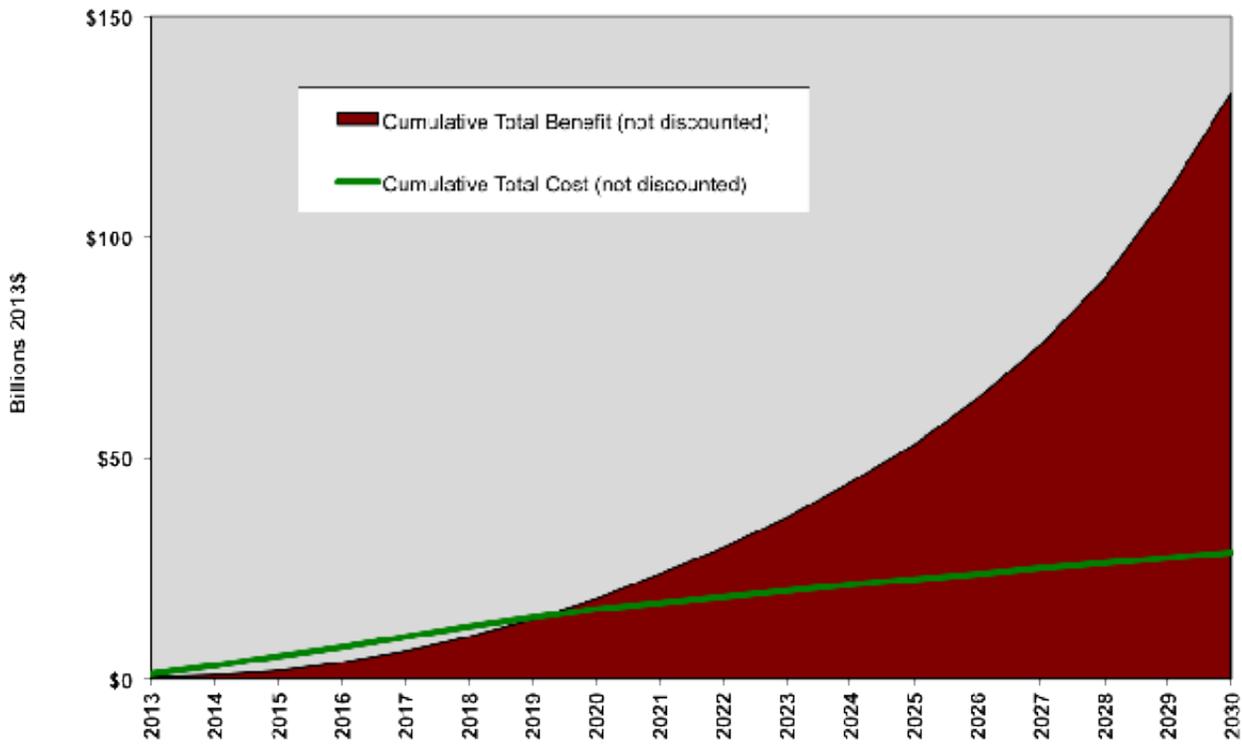


Figure 5. Cumulative Costs and Benefits of NextGen Mid-Term Improvements

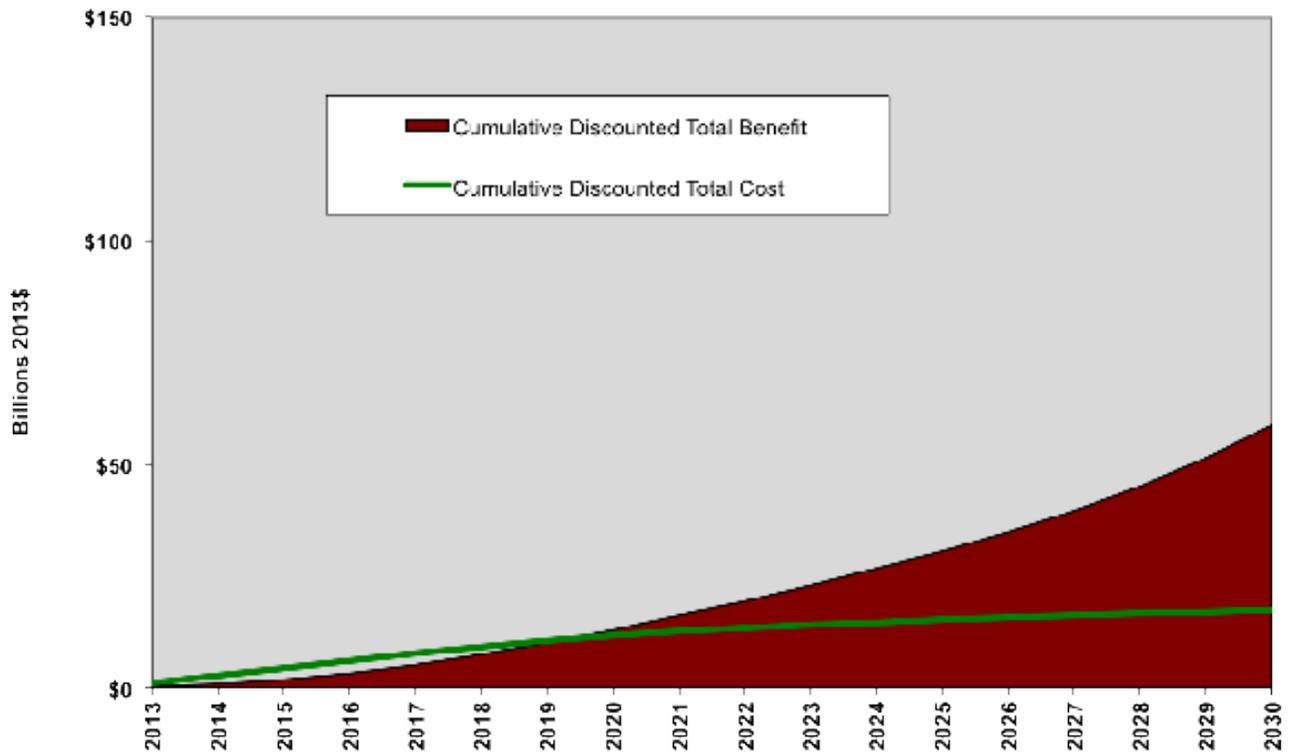


Figure 6. Discounted Cumulative Costs and Benefits of NextGen Mid-Term Improvements

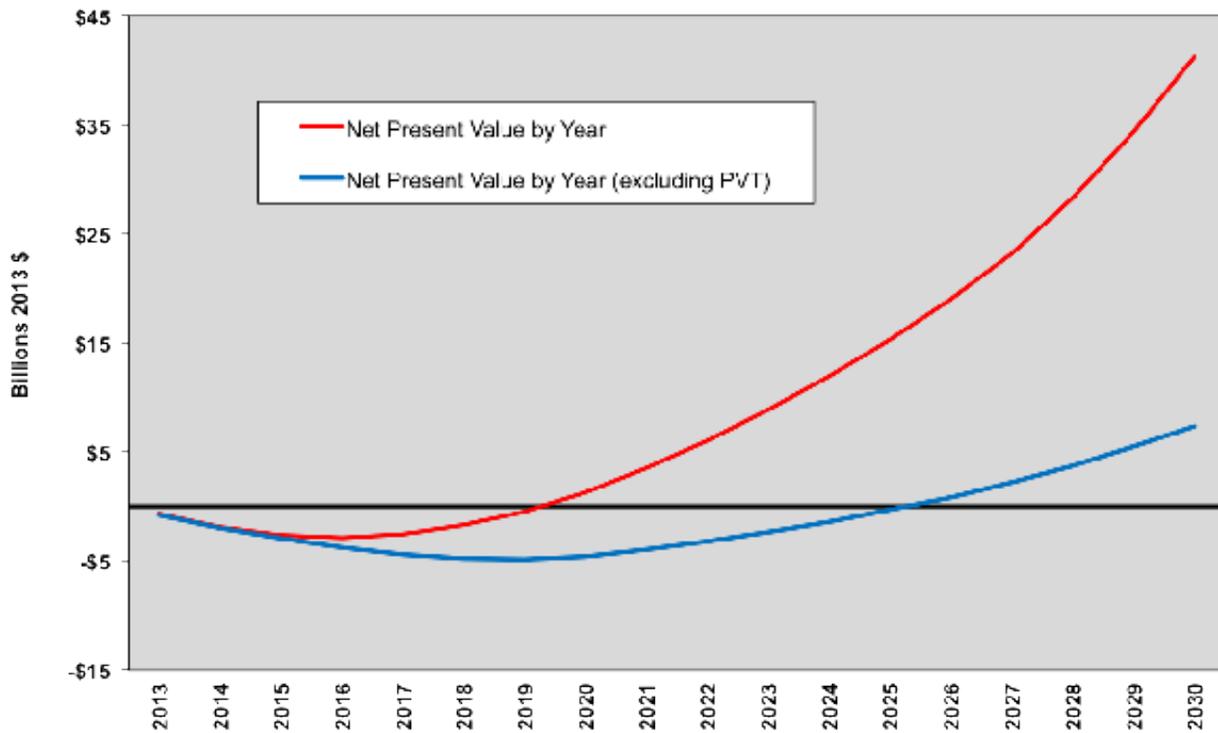


Figure 7. NextGen Mid-Term Investments Net Present Value (NPV) by Year

passenger time savings. Excluding these savings, NextGen still results in an NPV of \$7 billion and a breakeven in 2026, with a benefit-to-cost ratio of 1.4-to-1.

CONCLUDING THOUGHTS

The goal of NextGen is to take U.S. air transport firmly into the 21st century. There are many pieces to the program: research and development, ground infrastructure, computer software, airspace design, flight procedures and new aircraft avionics. In producing the business case report, we endeavor to link NextGen’s benefits with those investments and activities

that are necessary to generate them. We made an effort to capture all relevant costs and benefits.

Our analysis shows that by 2030, NextGen’s mid-term improvements will yield \$3.40 in benefits for every \$1 invested. It is our goal to continuously improve the quality of our forecasts of future benefits and costs. We anticipate that our estimates will change over time as our methodologies improve and as our expectations of future traffic and capacity evolve. But we do not expect the fundamental conclusion of this analysis to change — NextGen is a good investment for our country.



APPENDIX A: BENEFITS METHODOLOGY



This appendix explains how the FAA's system-wide model is used to evaluate benefits, which OIs are currently being modeled and which OIs are assessed using supplemental studies.

The interdependent nature of NextGen capabilities means that benefits must be calculated for the program as a whole rather than a sum of its components. NextGen's components are steps in a wide-ranging overhaul of the air traffic management system, not incremental improvements to the existing system. To the extent possible, the FAA's business case for NextGen recognizes this situation by taking an integrated approach to modeling system-wide benefits. A system-wide mathematical model of the NAS estimates the benefits of the entire program, to account for the interdependencies and non-linearity within the system. While the FAA's modeling capability has improved tremendously, modeling limitations remain. Many OIs cannot be adequately represented in the model. For this reason the benefits estimates produced by the model are augmented with detailed, discrete studies performed by FAA program offices and others when appropriate.

USING FAA'S SYSTEM-WIDE ANALYSIS CAPABILITY TO ESTIMATE BENEFITS

For the purposes of this analysis, NextGen benefits are considered the difference between a Base Case which includes no further enhancements beyond planned new runways and a NextGen Case that includes estimated capacity and efficiency improvements from the mid-term OIs that are modeled. While new runway infrastructure projects are at times considered part of the overall NextGen program, much of the cost of such projects is borne by local communities. Anticipated future runway infrastructure is not treated as a NextGen improvement in this report, but is instead included in the Base Case.

The FAA's SWAC is a fast-time simulation model used to estimate the potential operational benefits of improvements to the NAS. SWAC can calculate delay, canceled flights and fuel burn savings along with the potential for an increase in accommodated flights achieved by the various NextGen mid-term improvements working together.

At its core, SWAC is a discrete-event queuing model. NAS resources that may be capacity constrained, such as sectors, arrival or departure fixes, or airports, are represented as servers in the queuing model. SWAC contains server representations for all en route sectors in contiguous U.S. airspace, 310 domestic airports, terminal airspace at the 35 busiest airports and in-trail constraints for aircraft entering oceanic airspace.⁴ To represent the demand on those servers, each flight is modeled at a detailed level.

To generate the traffic demand on NAS resources, SWAC begins with actual flight data from the FAA's Traffic Flow Management System. Drawing from a representative set of historical days, all flights that filed an Instrument Flight Rules (IFR) flight plan and flew in the NAS are gathered as the baseline set of flights.⁵ These flights are then augmented with Visual Flight Rules (VFR) arrivals and departures from the FAA's Operations Network data. Current traffic levels are also projected into future years using the FAA's Terminal Area Forecast [5]. If this future traffic projection leads to demand at any airport that is infeasible, given the airport's capacity, then flights are removed. We assume these flights are not to be scheduled and flown.⁶

When looking at future scenarios, the FAA's airline fleet forecast is used to represent changes in the airframes being modeled. This is mainly done to more accurately represent

future fuel usage and carbon dioxide emissions. These aircraft are also modeled as having a certain avionics equipment, which changes over time. This equipment may be NextGen related, and can be used to modify planned route of flight (for example, Q-Routes can be selected, or continuous ascent or descent profiles specified). Equipment may also be used to affect how specific aircraft interact with model resources such as airspace sectors and airports. Each IFR flight has its trajectory computed and interpolated in 4-D using Eurocontrol's Base of Aircraft Data (BADA) [6], using historical data on winds aloft for the particular day being modeled.⁷ These interpolated trajectories, combined with assumptions about aircraft type, allow for detailed estimates of time in flight and fuel used.

Along with demand, capacity is a key component of the model. Sector capacity estimates are based on traffic flow management monitor alert parameters and are modified during simulation execution using National Convective Weather Diagnostic (NCWD) data. Airport capacities are estimated using MITRE's runwaySimulator model for at least three surface weather conditions for each airport: visual, instrument and marginal visual. Meteorological Aerodrome Report (METAR) data is then used by SWAC to determine local airport conditions and which airport arrival and departure capacities to use at any given time during the simulation. Historical weather data is obtained from the National Weather Service's National Climatic Data Center.

⁴ SWAC represents all IFR flights that enter, exit, or transition through U.S.-controlled airspace. However, some U.S. airports (310 for this analysis) are capacity constrained in the model. All other airports are assumed to have infinite capacity.

⁵ For this analysis a set of 16 days from FY2012 were used to represent the entire year. These days were selected using an optimization technique to ensure that derived annual totals for airports and Air Route Traffic Control Centers were as close to observed values as possible.

⁶ When NextGen improvements are projected to increase capacity at constrained airports, some of these removed flights may be added back in, which becomes a quantifiable benefit.

⁷ We use the National Centers for Environmental Prediction/National Center for Atmospheric Research Global Reanalysis Model wind and pressure estimates for the SWAC trajectory model.



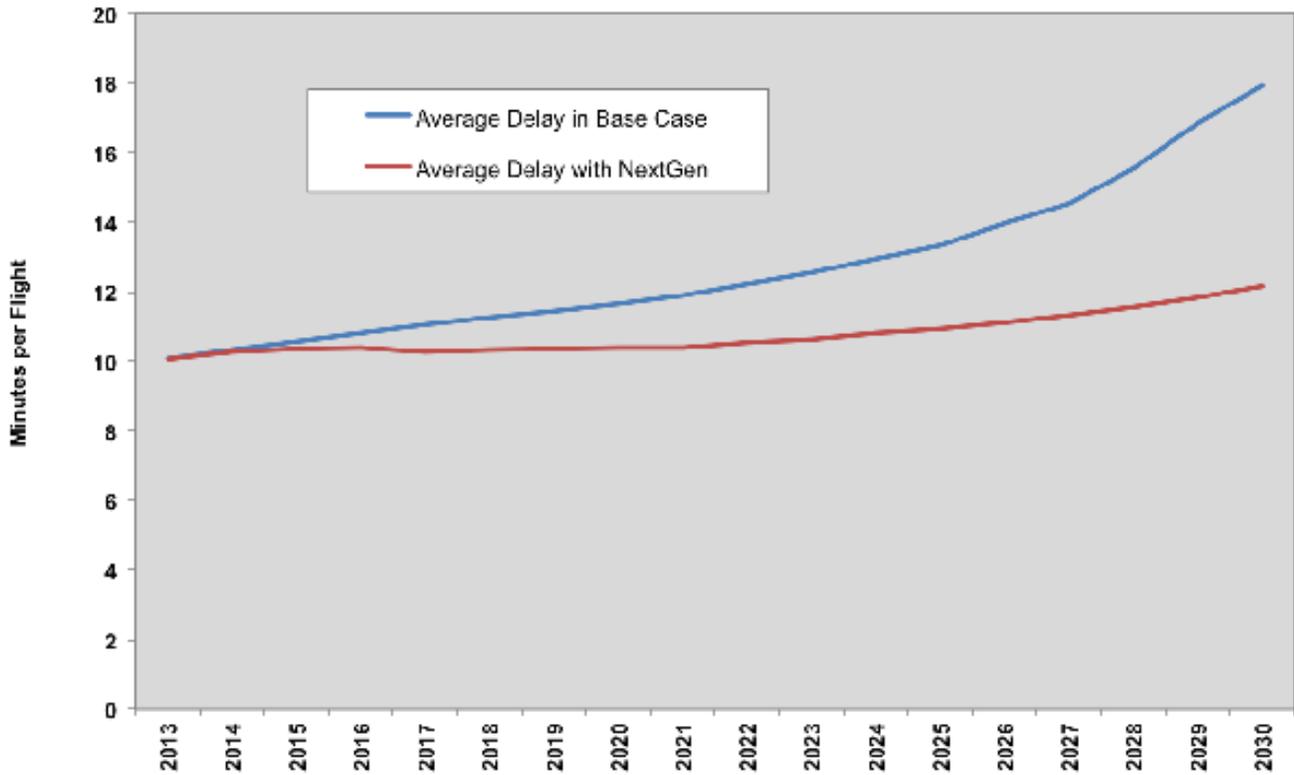


Figure 8. Average Delay Minutes per Flight from SWAC

The queuing model is run. As the simulation proceeds, an algorithm determines if any ground delay programs need to be implemented (to account for bad weather, for example). This computation allows for more accurate estimates of flight time, fuel usage, and sector congestion, by shifting delay to the surface that might otherwise have been taken in the air. Delays and corresponding fuel burn are computed. The resulting differences in flight times, scheduled flights and canceled flights between the NextGen Case and the Base Case represent the impact of NextGen. The valuation of these differences in dollar terms is covered in the next section.

The largest modeled benefits come from reduced delays. Although our modeling shows a marked improvement in delay minutes compared to a future without NextGen, delay in either case is forecast to increase. It will simply increase less with NextGen, as shown in Fig. 8. This is a consequence of the large increase in air traffic that the FAA forecasts over the next 20 years.

VALUING MODELED IMPROVEMENTS IN NAS PERFORMANCE

Differences between modeled performance with and without NextGen improvements are measured in the following categories:

Improvements in system capacity utilization

- Reductions in flight, taxi, and gate times and corresponding fuel use resulting from less delay
- Reductions in canceled flights
- Additional scheduled flights that are enabled by increased airport throughput

Improvements in system efficiency

- Reductions in flight times and fuel use due to more direct routings
- Reductions in flight times and fuel use due to more efficient climb and descent profiles

VALUING REDUCTIONS IN FLIGHT TIMES AND FUEL USE

To evaluate the monetary value of changes in flight times, we apply the FAA's standard method of using ADOC and PVT. This method is applied to any change in flight time — whether due to reductions in delay or improvements in flight efficiency.

ADOC

ADOC is used to estimate the impact of changes in flight times on aircraft operators. We start by using the FAA's official ADOC values [7], which include the costs of fuel and oil, crew and maintenance for large passenger carriers, cargo, military and general aviation. Because the SWAC model can estimate fuel use, which enables us to calculate the fuel cost directly, we exclude the fuel cost component from the initial ADOC values. We derive unique ADOC values, excluding fuel, specifically for each of the BADA aircraft types and user classes modeled in SWAC.⁸ Then the fuel cost is estimated separately based on the SWAC fuel consumption projection. The value of time and fuel savings for aircraft operators is the sum of crew and maintenance costs and fuel cost, given by the formula:

$$\begin{aligned} \text{Value of Time Savings (ADOC)} = & \sum_f \left[\text{minutes saved}_f \times \left(\frac{\text{crew and maintenance cost}}{\text{minute}} \right)_{a,u} \right] + \\ & \sum_f \left[(\text{excess fuel use})_f \times (\text{jet fuel price}) \right] \end{aligned}$$

Where

f = flight segment

a = BADA aircraft type

u = user class (commercial passenger service, cargo, etc.)

Value of Time Savings (ADOC)

PVT

Based on the latest guidance from the Department of Transportation, each hour of passengers' time is valued at \$45.20 in 2013, with 1.6 percent real growth each subsequent year [8]. Combining these PVT estimates with seat count and load factor estimates, the value of reduced flight time for passengers is calculated by:

$$\text{Value of Time Savings (PVT)} = \sum_f \left[\text{minutes saved}_f * \frac{\text{PVT}}{\text{minute}} * \text{seats}_{a,u} * \text{load factor}_u \right]$$

Where

f = flight segment

a = BADA aircraft type

u = user class (commercial passenger service, cargo, etc.)

Value of Time Savings (PVT)

⁸ For new aircraft types that are not yet in service, we chose a surrogate aircraft and then scaled the fuel cost by the estimated fuel consumption of the new aircraft. We estimated crew and maintenance costs using the new aircraft's anticipated seat count.

VALUE OF CARBON DIOXIDE REDUCTIONS

Reduced flight times and delays will also reduce fuel use. We estimate that NextGen will save 5.8 billion gallons of fuel through 2030. While the direct cost of fuel to aircraft operators is already included in the ADOC calculations above, the environmental benefits to society as a whole are not. We therefore need to value the positive externality of reduced carbon dioxide emissions. We convert fuel savings into carbon dioxide, using a standard conversion formula. Then we value the change in carbon dioxide using a concept known as the social cost of carbon (SCC). Annual values for the SCC have been estimated by the U.S. Interagency Working Group on the Social Cost of Carbon [9]. The resulting benefit valuation is given by the following formula:

$$\text{Value of } CO_2 \text{ Reduction} = (\text{gallons of fuel saved})_y * \left(\frac{21.095 \text{ lbs } CO_2}{\text{gallon of fuel}} \right) * \left(\frac{1 \text{ metric ton}}{2204.62 \text{ lbs } CO_2} \right) * (SCC_y)$$

Where

f = flight segment

a = BADA aircraft type

u = user class (commercial passenger service, cargo, etc.)

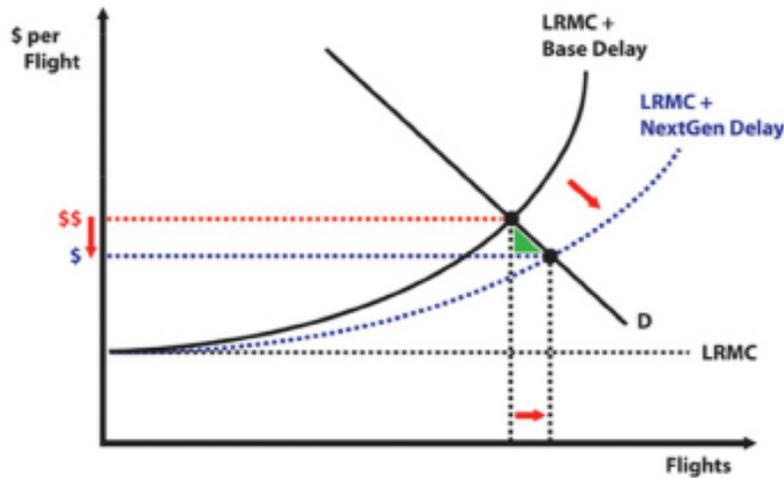
Value of CO₂ Reduction



VALUING ADDITIONAL FLIGHTS ENABLED

Capacity increases will allow more flights to be scheduled and flown at capacity-constrained airports. Counting the benefit of reduced delay for existing flights is not sufficient. However, we must be careful when valuing these additional flights. It would be incorrect to count additional revenue generated. This would be the average ticket price multiplied by the number of additional passengers served. In general, air carrier revenue is a transfer from passengers to flight operators in exchange for a service provided. If the service was not provided, passengers would have spent their money elsewhere. However, the benefit from additional flights can be estimated using the concept of consumer surplus. While a thorough treatment of the concept of consumer surplus is beyond the scope of this report, this surplus reflects the consumers' "willingness to pay" for a product or service. In general, there are many consumers who are willing to pay more than the market price for the service, in this case air transportation. The sum total of this willingness to pay across all consumers in the market is the consumer surplus. If the cost to consumers goes down, consumer surplus increases because more people pay less than they otherwise would for the same service.

The reason we expect there to be additional flights in a NextGen future is that we expect a reduction in the cost of providing these flights, which should translate to decreased ticket prices. In this case, the decrease in cost is brought about by reduced delays. Thus, new flights are valued using the marginal reduction in delay cost, multiplied by the marginal increase in the number of flights enabled by this delay cost reduction. Graphically, this is the area under the demand curve between the old and new number of flights, as shown in Fig. 9.



LRMC is “Long Run Marginal Cost”, defined as the cost of providing a flight in the absence of delay

LRMC is “Long Run Marginal Cost”, defined as the cost of providing a flight in the absence of delay

Figure 9. NextGen’s Impact on Supply and Demand Relationships for Air Transportation Services

Assuming a linear demand curve with a slope of -1, the value of additional flights is then given by the equation:

$$\text{Value of Additional Flights} = \frac{1}{2} (\Delta \text{ delay cost}) * (\Delta \text{ flights})$$

Value of Additional Flights

VALUING REDUCTIONS IN THE NUMBER OF CANCELED FLIGHTS

Flight cancellations are costly to airlines and passengers. However, at some point it is preferable to cancel a flight rather than incur even higher costs if delays become excessive.

There is no generally accepted cost of cancellations for use in government cost-benefit studies, as there is with ADOC or PVT. However, several studies have investigated the issue, and we rely on two of them [10], [11]. Based on these studies, aircraft operators are assigned a fixed cost of \$4,977 per cancellation, while the cost to passengers is based on applying PVT values to an estimated average of 457 minutes of disrupted passenger delay per canceled flight⁹. Mathematically, these are calculated as follows:

$$\text{Value of Reduced Cancellations (airlines)} = (\Delta \text{ cancelled flights}) * \left(\frac{\$4,977}{\text{Flight}} \right)$$

Value of Reduced Cancellations (passengers)

$$= (\Delta \text{ cancelled flights}) * \left(\frac{\text{PVT}}{\text{min}} \right) * \left(\frac{457 \text{ min}}{\text{passenger}} \right) * \left(\frac{\text{passengers}}{\text{flight}} \right)$$

Value of Reduced Cancellations

⁹ This estimated value of passenger delay includes the average time lost due to having to re-book on a different flight.

MID-TERM OPERATIONAL IMPROVEMENTS MODELED

A subset of NextGen-enabled improvements to the operating environment that are captured in this analysis have been modeled in SWAC. As mentioned earlier, this is due to current model limitations. Nevertheless, nearly 85 percent of the cumulative benefits by value reported here are derived from SWAC outputs. Remaining benefits are based on FAA Program Office studies. Tables 1 and 2 present those OI currently modeled.¹⁰ As the SWAC model continues to develop, it will identify and capture a greater share of total benefits.

Table 1. Operational Improvements Modeled in SWAC

Portfolio	Operational Improvements
Automation Support for Time-Based Flow Management	Implement TMA at Additional Airports (104115-12)
	Extended Metering (104120-11)
	Use RNAV Data to Calculate Trajectories (104123-11)
	Ground-Based Interval Management (104123-12)
	Interval Management - Cruise (102118-21)
	Meet TBFM Constraints Using RTA Capability (104120-22)
	Time-Based Metering in the Terminal Environment (104128-24)
Improved Multiple Runways Operations	Wake Turbulence Mitigation for Departures (102140)
	7110.308 Procedures (102141-11)
	Wake Turbulence Mitigation for Arrivals - Procedures (102141-11)
	Independent Runway Separation Standards (102141-13)
	Dependent Runway Separation Standards (102141-14)
	Paired Approaches Runways Spaced Less Than 2,500 ft CAT I (102141-21)
	Paired Approaches Runways Spaced Less Than 2,500 ft CAT II (102141-25)
Wake Turbulence Mitigations for Arrivals - Systems (102144-21)	
Improved Approaches and Low-Visibility Operations	Initial Tailored Arrivals (ITAs) (104124-11)
	Optimized Profile Descents (104124-12)
	GBAS Category I (107107-11)
	EFVS to 100 ft (107117-11)
	EFVS to Touchdown (107118-11)
Performance Based Navigation	RNAV SIDs/STARs (107103-13)
	Optimization of Airspace and Procedures in the Metroplex (108209-12)
	Transition to PBN Routing for Cruise Operations (108209-14)
	Speed Advisory Support for Merging Aircraft on RNAV Procedures (108209-15)
Separation Management	Improved Arrival and Departure Management: Airspace Enhancements (104122-23)
	Wake Re-Categorization Phase I (102154-11)
	ADS-B Separation (102123)
	Initial Conflict Resolution Advisories (102114)
	Automation Support for Separation Management (102137)
	Spaced-Based ADS-B (102137-33)
	Expanded Use of 3nmi Separation in Transition Airspace (104122-21)
	Wake Re-Categorization Phase II (102154-21)
Interval Management - Defined Interval (102148-01)	
Surface	Initial Surface Management System (104209-17)
	Remote Operations at Non-Tower Airports (102153-02)
Collaborative Air Traffic Management	Flexible Airspace Management (108206)
NAS Infrastructure	Initial En Route Datacomm Services

¹⁰ The numbers in parentheses are the identifiers for the operational improvements in the FAA's NAS Enterprise Architecture [12].

Table 2. Programs with Benefits Not Included in Table 1 (Estimated from Other Sources)

Programs with Benefits not Modeled in SWAC
Aeronautical Information Management
Collaborative Air Traffic Management Technologies
Colorado Wide Area Multilateration
Data Communications - FAA Efficiency Benefits & Tower Departure Clearance Services
NextGen Weather Processor
Surveillance and Broadcast Services - ADS-B Safety, Efficiency, and Cost Avoided Benefits
System Wide Information Management
Terminal Flight Data Manager
Time-Based Flow Management



APPENDIX B: COST METHODOLOGY

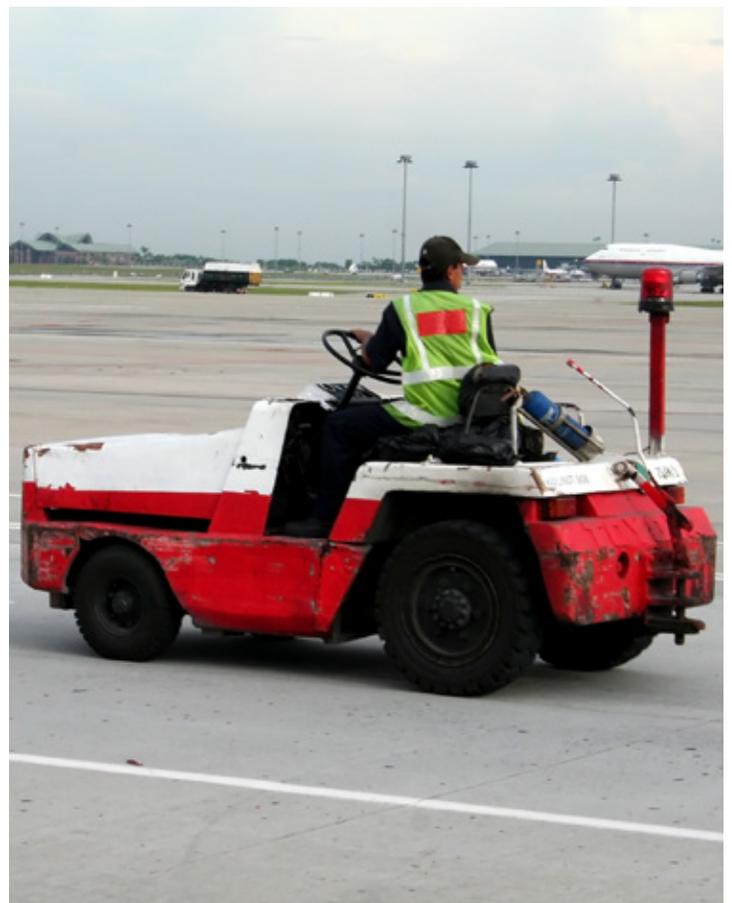


Implementing NextGen will require significant investments from the FAA to fund the deployment of NextGen technologies, as well as from aircraft operators. Operators are responsible for ensuring that their aircraft are properly equipped to maximize performance in the future NAS. This chapter discusses the projected costs of mid-term NextGen improvements for the FAA and aircraft operators, along with the methodology used to derive them.

COST TO THE GOVERNMENT

FACILITIES AND EQUIPMENT (F&E)

Estimates of the FAA's costs to develop and implement NextGen technologies are derived from internal agency budget estimates. The agency's F&E budget request for the next five fiscal years is published in the CIP. The budget numbers in the CIP come from bottom-up cost estimates that are developed by individual capital programs within the FAA. For many NextGen programs the published five-year time horizon does not cover their entire development period. In these cases, the published CIP must be supplemented with cost estimates provided by the individual FAA program offices. The NextGen F&E budget consists of



transformational programs, implementation programs and pre-implementation activities. The programs and activities in each of these categories are listed in Table 3.

The official budget request for each of these F&E activities can be found in the latest published CIP. The estimated F&E costs for 2013 are based on CIP requests for 2014-2018.

Table 3. Categories of NextGen F&E Expenditures

Transformational Programs	Implementation Programs	Pre-Implementation Activities
Automatic Dependent Surveillance – Broadcast	Time-Based Flow Management	NextGen Demonstrations and Infrastructure Development
System-Wide Information Management	Colorado Wide Area Multilateration	NextGen System Development
Collaborative Air Traffic Management Technologies	Aeronautical Information Management	NextGen Trajectory Based Operations
Data Communications	En Route Automation Modernization	NextGen Reduce Weather Impact
National Airspace System Voice System	NextGen Future Facilities	NextGen Arrivals/Departures at High Density Airports
	Performance Based Navigation	NextGen Collaborative Air Traffic Management
	Terminal Flight Data Manager	NextGen Flexible Terminals and Airports
	Security Integrated Tool Set Work Package 1	NextGen Safety, Security, and Environment
	Aviation Safety Information Analysis & Sharing	NextGen Systems Networked Facilities
	NextGen Weather Processor	

The estimated F&E costs for 2014 are based on the FAA’s proposed CIP 2015-2019, as submitted to the Office of Management and Budget. They do not reflect changes contained in the final FY2015 Presidential Budget request. However, the budget estimates used for this report are consistent with the assumptions underlying the benefit estimates presented in other sections.

R&D AND RELATED COSTS

The agency’s Research and Development (R&D) budget needs are laid out in the National Aviation Research Plan covering the next five fiscal years [13]. As with the CIP, we must also go beyond this horizon to accurately assess the cost of NextGen R&D. Unlike FAA capital programs, the exact allocation of these R&D funds is nearly impossible to predict beyond a few years out. Along with the pre-implementation activities, we make the assumption that R&D funding used on mid-term OIs will gradually diminish as the time horizon for deployment of all mid-term technologies nears completion around 2020.

OPERATIONS AND MAINTENANCE

Capital programs entail not only an investment component, but also impose ongoing costs for O&M. Estimated O&M costs are presented in the business cases for individual programs as they seek approval to move forward. O&M is



considered in the FAA’s decision making whether to fund the investment. O&M is not an explicit component in the capital budget, but is instead included in the agency’s overall operations account. For this reason, we need to separately estimate the O&M component.

Where available, we have included O&M costs taken from the

approved business cases of NextGen programs. For capital programs that do not yet have an approved business case, we have applied the average annual O&M cost. The O&M cost is 5 percent of the total F&E investment.

Fig. 10 shows the total estimated FAA cost for NextGen programs, broken out by F&E, R&D and Ops, and O&M.

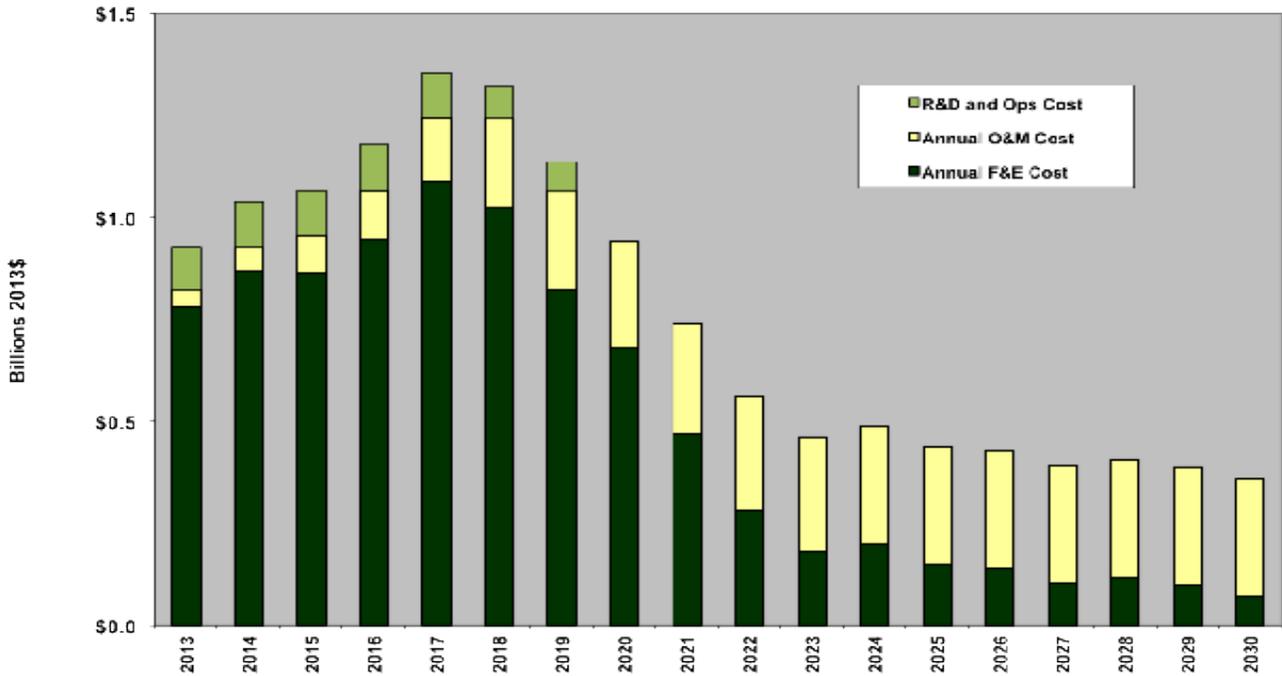


Figure 10. Annual FAA Cost for NextGen Mid-Term Capabilities

COSTS TO AIRCRAFT OPERATORS

A large number of mid-term OIs require not only FAA infrastructure and procedures, but also avionics onboard the aircraft. In the case of PBN and data communications via the



Future Air Navigation System (FANS) 1/A+, versions of the necessary avionics are available and are already on board many aircraft. In the case of ADS-B Out, solutions are being made available, while others await certification. For ADS-B In, some avionics are available, but standards are still evolving and development is ongoing.

The benefits contained in this report assume a certain equipage level throughout commercial and general aviation fleets. That does not necessarily mean that aircraft operators must equip at these levels, but it does constitute what may be considered an expected level of equipage. To be consistent with our benefit estimates, the costs we estimate for avionics are based on this expected level.

Operators can install new avionics on existing aircraft (retrofit) or purchase a new aircraft with the avionics already installed (forward fit). Generally, a retrofit is assumed to be more

expensive than a forward fit because it involves taking the aircraft out of service to install new equipment. Forward fits are assumed to include only the cost of hardware and software, while retrofits also include the additional cost of installation¹¹.

Avionics packages have different costs, with FANS 1/A+ and ADS-B Out generally being the least expensive and RNP and

ADS-B In being the most expensive. The cost to retrofit avionics, for example RNP, can vary depending on aircraft type and date of manufacture. For this analysis, we used an estimated average cost by major aircraft type, split between forward fit and retrofit. Our unit cost estimates, shown in Table 4, were derived from work done by MITRE in support of the RTCA NextGen Mid-Term Implementation Task Force [14].

Table 4. Estimated Unit Cost (Installed) for Major NextGen Avionics Packages

Unit Cost by Aircraft Type (thousands Fiscal Year 2012 dollars)								
	Data Communications (FANS 1/A+)		ADS-B Out		ADS-B In (CDTI)		RNP 0.3 with RF Legs	
	Retrofit	Forward Fit	Retrofit	Forward Fit	Retrofit	Forward Fit	Retrofit	Forward Fit
Commercial								
Widebody	\$80	\$40	\$135	\$70	\$500	\$300	\$525	\$260
Narrowbody	\$80	\$40	\$150	\$70	\$500	\$300	\$525	\$260
RJ	\$80	\$40	\$130	\$70	\$500	\$300	\$525	\$260
TurboProp	\$80	\$40	\$150	\$70	\$500	\$300	\$525	\$260
General Aviation								
GA Turboprops	\$80	\$40	\$15	\$10	\$30	\$30	\$260	\$130
GA Jets	\$80	\$40	\$15	\$10	\$30	\$30	\$260	\$130
GA Piston	N/A	N/A	\$14	\$8	\$30	\$30	N/A	N/A

MITRE provided estimates of current levels of avionics equipage. Combining current equipage levels with target future equipage levels and applying unit cost estimates results in the total

cost of avionics investment required, shown in Fig. 11. We anticipate these numbers will change as we work to improve our modeling of this important component.

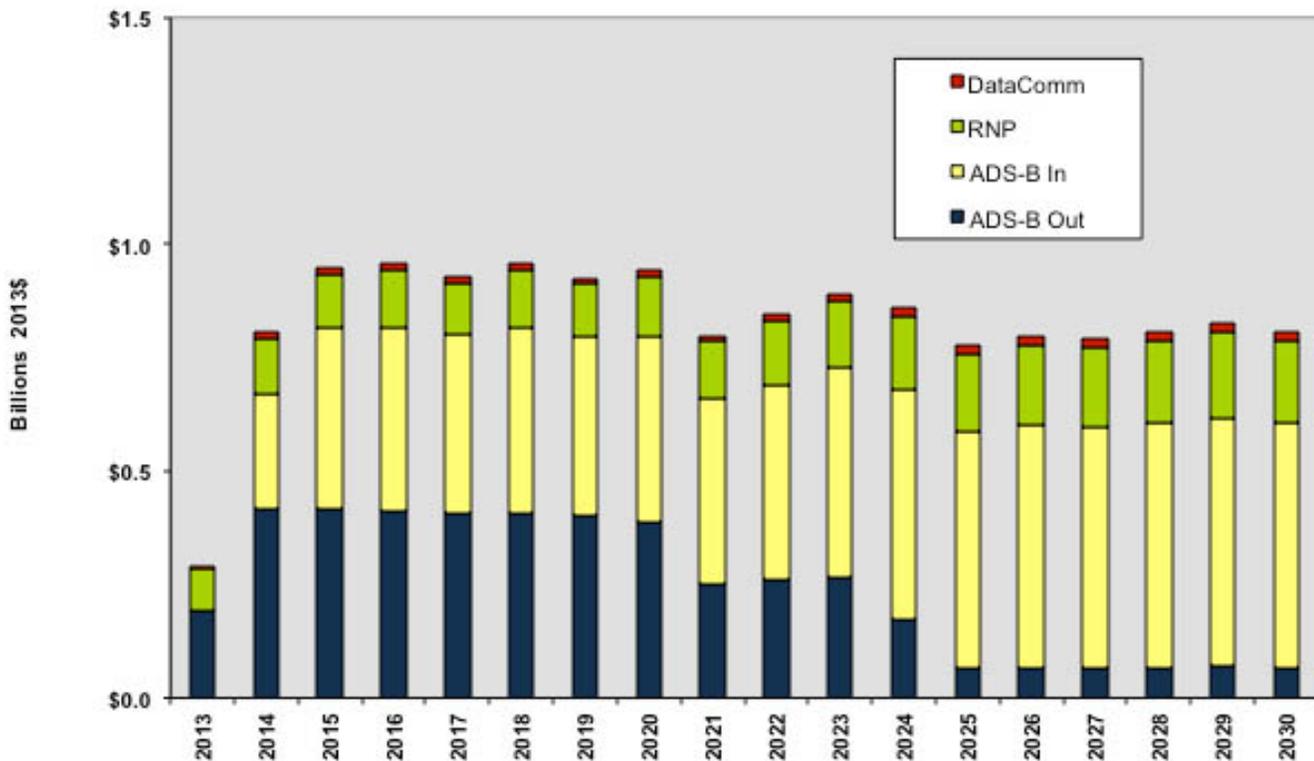


Figure 11. Estimated Annual Operator Investment in NextGen Avionics by Type

¹¹ Our estimated retrofit costs include direct installation. They do not include the opportunity cost of taking an aircraft out of service or ancillary costs such as training, etc.



It is worth emphasizing that estimating the total cost to equip the fleet is difficult. Not only are the costs to equip highly variable by aircraft type and airframe type, costs can also vary depending on whether avionics are installed separately or in combination. Combining avionics installations minimizes

installation cost. As we are trying to be conservative in our cost estimates, we assumed that each avionics package would be installed separately. In reality, operator decisions to jointly retrofit with multiple technologies would likely reduce their costs.

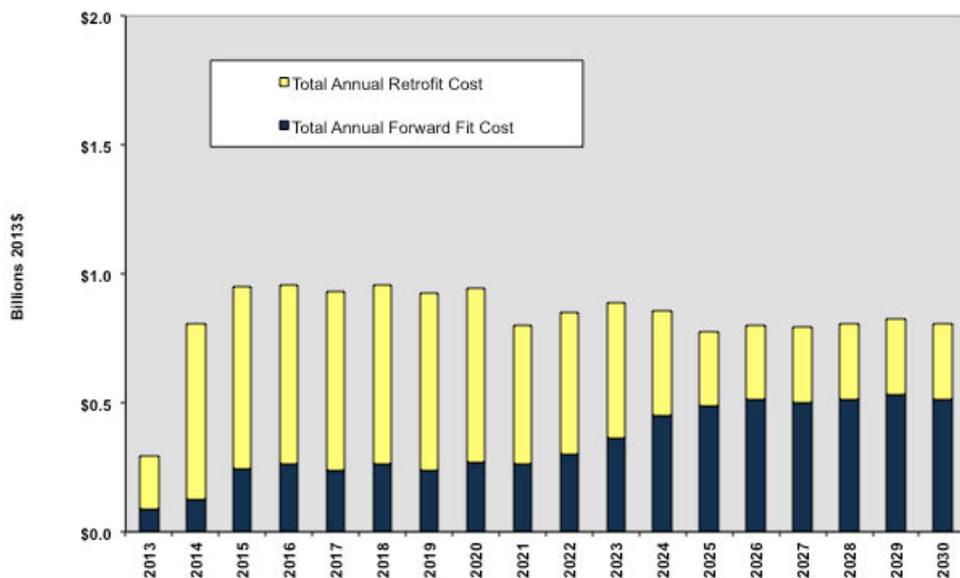


Figure 12. Estimated Annual Operator Investment in NextGen Avionics, Retrofit vs. Forward Fit

APPENDIX C: CHANGES IN OUR ESTIMATES OVER TIME

The FAA's goal is to provide the latest and best estimates of NextGen costs and benefits.

NextGen is the umbrella program the FAA uses to manage the modernization of the National Airspace System. As such, the components of NextGen are in various stages of maturity. Many of the NextGen operational improvements are already embodied in programs with approved business cases. Their costs and benefits are well-understood. At the other end of the spectrum are those operational improvements that are still in concept development. They do not yet have approved business cases, thus estimates of their costs, schedules and performance are still fluid. As program plans mature, however, we need to update our overall cost and benefit estimates to reflect the latest information.

In addition to program plans, other factors influence the cost and benefit estimates presented in this report, including:

- Forecasts of future air carrier fleets and air traffic,
- Current values for airline operating costs, including fuel,
- Assumptions regarding future airport infrastructure,
- Estimates of the value of passenger time, and
- Improvements to the FAA's system-wide analysis capability (SWAC) fast-time simulation model.

To ensure our cost and benefit estimates are current, we revise them annually using the most up-to-date data. The progression of our estimates as contained in previous versions of this document is presented in the tables below.

Cumulative Benefit Estimates through 2030 (adjusted for inflation)			
(in \$ billions)	Year of Business Case		
	2012	2013	2014
Avoided Delay	\$76.9	\$154.4	\$99.6
Reduced Flight Time	\$1.7	\$5.9	\$4.6
Fewer Flight Cancelations	\$9.6	\$3.4	\$9.0
Reduced CO ₂	\$1.1	\$0.4	\$0.4
Other Benefits not Modeled in SWAC*	\$16.6	\$17.7	\$18.9

* Safety, FAA cost savings, etc.
Detail may not sum to total because of rounding.

Cumulative Cost Estimates through 2030 (adjusted for inflation)			
(in \$ billions)	Year of Business Case		
	2012	2013	2014 ¹²
FAA Capital Cost (F&E)	\$10.3	\$11.2	\$8.9
FAA Ops and R&D directly for NextGen	\$1.0	\$1.1	\$0.7
FAA Ongoing O&M (estimated)	\$7.2	\$7.6	\$4.0
Aircraft Operators' Cost to Equip	\$18.8	\$18.8	\$15.0
Total	\$37.4	\$38.7	\$28.6

Detail may not sum to total because of rounding.

This business case has only been published since 2012. However, the same modeling methodology has been used to generate shorter-term estimates reported in the NextGen Implementation Plan (NGIP), which has a longer history. Like the Business Case for NextGen, these NGIP estimates have also shown variability over time.

Summary of NextGen Benefits Changes as Reported in the NextGen Implementation Plan

	NextGen Implementation Plan				
	2010*	2011	2012	2013	2014 ¹³
Total Benefits (through 2020)	\$22 B	\$23 B	\$24 B	\$38 B	\$18 B
Total Fuel Savings (through 2020)	1.4 B gal	1.4 B gal	1.4 B gal	1.6B gal	0.8B gal
Delay reduction in FY20	-21%	-35%	-38%	-41%	-11%

* The 2010 NGIP used 2018 as its forecast horizon, not 2020

¹² As of the 2014 publication, we moved toward a more accepted business case methodology of excluding sunk costs. Thus, the 2014 document includes costs from 2013 - 2030, while prior estimates included costs from 2007 - 2030. Note that benefits estimates have always been forward looking, covering the first forecast year through 2030.

¹³ The content of the NextGen Implementation Plan changed in 2014, and these benefits estimates were not included. However, we have included here equivalent estimates through 2020.

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ACRONYMS AND ABBREVIATIONS

4-D	Four Dimensional	NAS	National Airspace System
ACM	Adjacent Center Metering	NCWD	National Convective Weather Diagnostic
ADOC	Aircraft Direct Operating Cost	NextGen	Next Generation Air Transportation System
ADS-B	Automatic Dependent Surveillance–Broadcast	NPV	Net Present Value
ADS-C	Automatic Dependent Surveillance–Contract	NVS	NAS Voice System
ARTCC	Air Route Traffic Control Center	O&M	Operations and Maintenance
ASIAS	Aviation Safety Information Analysis and Sharing	OI	Operational Improvement
ATC	Air Traffic Control	PBN	Performance Based Navigation
BADA	Base of Aircraft Data	PVT	Passenger Value of Time
CATM	Collaborative Air Traffic Management	R&D	Research and Development
CATMT	Collaborative Air Traffic Management Technologies	RNAV	Area Navigation
CIP	Capital Investment Plan	RNP	Required Navigation Performance
DoD	Department of Defense	RTCA	Aviation Industry Group
FAA	Federal Aviation Administration	SCC	Social Cost of Carbon
F&E	Facilities and Equipment	SUA	Special Use Airspace
FANS	Future Air Navigation System	SWAC	System Wide Analysis Capability
GBAS	Ground Based Augmentation System	SWIM	System Wide Information Management
GPS	Global Positioning System	TBFM	Time-Based Flow Management
IFR	Instrument Flight Rules	TBM	Time-Based Metering
ITP	In-Trail Procedure	TMA	Traffic Management Advisor
METAR	Meteorological Aerodrome Report	VFR	Visual Flight Rules

Why NextGEN Matters

The movement to the next generation of aviation is being enabled by a shift to smarter, satellite-based and digital technologies and new procedures that combine to make air travel more convenient, predictable and environmentally friendly.

As demand for our nation's increasingly congested airspace continues to grow, NextGen improvements are enabling the FAA to guide and track aircraft more precisely on more direct routes. NextGen efficiency enhances safety, reduces delays, saves fuel and reduces aircraft exhaust emissions. NextGen is also vital to preserving aviation's significant contributions to our national economy.

- NextGen provides a better travel experience, with less time spent sitting on the ground and holding in the air.
- NextGen gets the right information to the right person at the right time.
- NextGen reduces aviation's adverse environmental impact.
- NextGen lays a foundation for continually improving and accommodating future air transportation needs while strengthening the economy locally and nationally.
- NextGen increases airport access, predictability and reliability.
- NextGen enables us to meet our increasing national security and safety needs.
- NextGen safety management helps us to proactively identify and resolve potential hazards.
- NextGen brings about one seamless, global sky.



U.S. Department of Transportation
Federal Aviation Administration

Office of NextGen
800 Independence Avenue, SW
Washington, DC 20591
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